PALEOENVIRONMENTAL SIGNIFICANCE OF C AND O ISOTOPIC SIGNAL IN LAST INTERGLACIAL GASTROPOD *DENDROPOMA* SHELL CONCENTRATIONS FROM CANARY (SPAIN) AND SAL (CAPE VERDE) ISLANDS

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Resumen: Se estudia el significado paleoambiental de los isótopos estables de C y O de la concha del gasterópodo irregular *Dendropoma*, considerado un marcador del nivel medio del mar, procedentes de terrazas pertenecientes al Ultimo Interglaciar de Fuerteventura y Lanzarote (Islas Canarias, España), y de la isla de Sal (Cabo Verde). Se compara con la señal actual de *Dendropoma* sp. de la isla de Sal, y *D. petraeum* del Cabo de Palos (Murcia, España). El rango de valores es casi siempre menor a 1 ä, excepto para ä^{13}C de los ejemplares de Fuerteventura (3,57 ‰) y ä^{18}O de los de Cabo de Palos (2,09‰). La diferencia entre ä^{18}O de los ejemplares de Fuerteventura con respecto a los de la isla de Sal, si la salinidad no cambió, probablemente refleja una diferencia de 3-4 ºC en la temperatura de la superficie del agua del mar (SST) de ambas zonas, similar a la que existe actualmente. Para la isla de Sal, en ausencia de cambios de salinidad y volumen de hielo, la diferencia de SST entre el Ultimo Interglacial y el Presente Interglacial sería de 2 ºC.

Palabras clave: Isótopos estables de C y O, paleoambientes, gasterópodos, Ultimo Interglaciar, Canarias, Cabo Verde.

Abstract: We study the paleoenvironmental significance of the C and O isotopes of the irregular coiled gastropod *Dendropoma*, a remarkable biological marker of mean sea level, of sediments aged as Last Interglacial from Fuerteventura and Lanzarote (Canary Islands, Spain), and from the Sal Island (Cape Verde). Recent *Dendropoma* sp. from the Sal Island and *D. petraeum* from Cabo de Palos (Murcia, Spain) are also utilized. Range of results generally is lower than 1 ä, both for the C and O, except for the ä^{18}O in Cabo de Palos (2,09‰), and for the ä^{13}C from Fuerteventura (3,57‰). Differences between ä^{18}O shells of the Last Interglacial (LI) from Fuerteventura with respect to that of Cape Verde, if salinity do not changed, probably reflects differences of 3-4 ºC in the sea surface temperature (SST), similar to the Recent. In Sal Island, if salinity and ice-volume do not changed, the difference between SST of the LI and Recent probably was of 2 ºC.

Key words: Stable isotopes of C and O, paleoenvironments, gastropods, Last Interglacial, Canary Islands, Cape Verde.

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The Vermetid *Dendropoma* is an irregular-coiled gastropod, and some of their species form dense paucispecific aggregations on rocky shores at the lower intertidal level, in areas semi-exposed to wave action. Because their food requirements –they are mainly ciliariy suspension feeders-, their life habitat require environments frees of pollution, turbulent waters, and with low sedimentation rates (Calvo *et al.*, 1998).

Although Mediterranean recent species of the genus, *D. petraeum* (Monterosato), have a lecithotrophic development (Calvo *et al.*, 1998), without a pelagic larval phase, the geographical range extension of this taxon is relatively wide. It is present in the warmest areas of the Mediterranean Sea and extend until the close Atlantic waters. In the Spanish Mediterranean coasts, *Dendropoma petraeum* develops dense aggregations in their warmest sector, between la Nao Cape and Gata Cape (SE Spain), and in the Southern Balearic Islands (Ibiza and Formentera). It is also present along the Alboran Sea until the Atlantic coast of Conil de la Frontera (Cádiz) (Calvo, 1999). It has been also recorded in Corsica, Sicily, Tunisia, Malta, Crete, Syria, Lebanon and Israel (Moliner and Picard, 1954; Fevret and Sanlaville, 1966; Safriel, 1974; Laborel, 1987; Al-Nimeh and Elassafin, 1996; Azzopardi and Schembri, 2000). A plausible explanation of the wide geographical range and of its presence in such isolated islands as Alboran or

Columbretes (about 80 and 60 km respectively from the nearest coast) may be that the sticky mucous trail secreted by the pedal gland of the crawling young snails before attachment allows relatively long dispersal distances by marine currents. (Hughes, 1979; Calvo *et al.*, 1998).

As a result of this wide geographical distribution, the shell aggregations of *Dendropoma* acquire great importance in paleoenvironmental reconstructions, because they are considered as «remarkable biological marker of mean sea level» (Fevret and Sanlaville, 1966; Laborel, 1987; Pirazzoli *et al.*, 1991; Antonioli *et al.,* 1999).

Many studies of paleoenvironmental information based on stable C and O isotopes from mollusks have been carried in the past (i.e. Krantz *et al.*, 1987; Klein *et al*, 1996 among others), including the Gulf of Guinea and Canary Islands (Cornu *et al.,* 1993; González Delgado *et al.*, 1998, 2000). Howewer, isotopic studies on *Dendropoma* are very scarce: Antonioli *et al.* (1998) recognized the medieval Little Ice Age from Oxygen stable isotopes of *D. petraeum* from the Tyrrenian Sea. In this work, we study stable C and O isotopes in *Dendropoma* tubes collected from coeval localities widely apart from each other but very similar in age, in order to contribute to explain paleoenvironmental changes of the water masses in that the gastropods grew. The preliminary isotopic results, related to 15 samples, were advanced in González Delgado *et al*. (2003).

Material and methods

35 stable isotopic (C and O) samples were obtained from several specimens of *Dendropoma* shell aggregations genetically related to Last Interglacial deposits in Eastern Canary Islands: Lanzarote and Fuerteventura (Spain), and from Sal island (Cape Verde) (Fig. 1). The specimens from Lanzarote are located in «Caleta de Famara» (N of Teguise, coordenates: N 29º 7' 1.2"; W 13º 33' 45.4"), and are aged as 129 ± 5,1 ka (OIS 5e, Zazo *et al.*, 1997). Samples from Fuerteventura island come from «Punta del Tigre» (Jandía peninsula, coordenates: N 28º 4' 43.1"; W 14º 30' 6.8", Fig. 2), correlated with marine Episode XI (OIS 5e, Zazo *et al.*, 2002). The shells from Sal island (Cape Verde) come «Punta do Leme Velho», and its age probably corresponds to OIS 5e.

The taphonomic signature of the *Dendropoma* concentrations studied, mainly the presence of common life positions of the shells, preservation of the growth stages, very low pre-burial fragmentation and abrasion, and preservation of colour traces, suggest that the samples collected closely correspond to *in situ* agregations.

In order to compare the isotopic results with that of extant *Dendropoma*, we have also sampled recent specimens of *D. petraeum* (Monterosato), from the coast of Cabo de Palos (Murcia, SE Spain), and

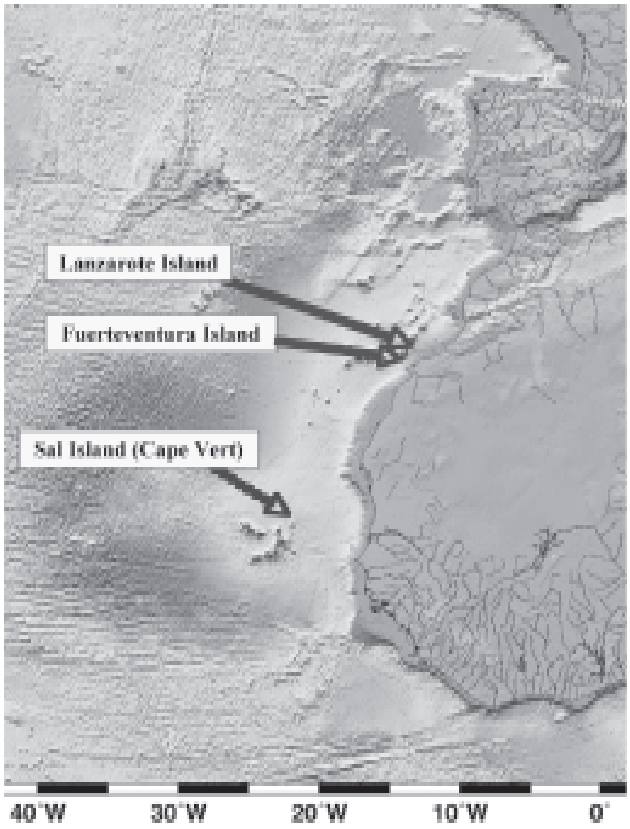

Figure 1.- Location map.

Dendropoma sp. from the Sal island (Cape Verde): North of Calheta de Fiura.

After ultrasonic cleaning and removal of occasional surface microborings with a dental microdrill, shells were micro-drilled longitudinally or reduced to powder in an agata mortar. The aim was to obtain an average of the life span of the animal. The organic material of the shells was eliminated in a plasma asher during a half hour. The isotopic analyses were carried out at the Servicio General de Isótopos Estables de la Universidad de Salamanca, with a mass-spectrometer VG Prism-II. All the results are referred to standard PDB. Analytical precision of samples was 0.074‰ for the Oxygen, and 0.161**%** for the Carbon (n=4).

Results and discussion

Isotopic results are shown in table I. The range and average values are plotted in table II. Both C and O data have differences between the diverse shells of the same locality. Ranges of isotopic signal are always higher in $\delta^{13}C$ than in $\delta^{18}O$, and generally are lower than 1‰. The highest range of $\delta^{13}C$ corresponds to the Last Interglacial *Dendropoma* sp. from Fuerteventura, reaching 3.57‰, and for the $\delta^{18}O$, to the recent mediterranean *Dendropoma petraeum*, reaching 2.09‰.

If we considere the isotopic signal of the recent shells, the mediterranean *D. petraeum* from "Cabo de Palos", shows a range of 1.11‰ for the Carbon and 2.09δ for the Oxygen. On the contrary, in recent *Dendropoma* sp. of the

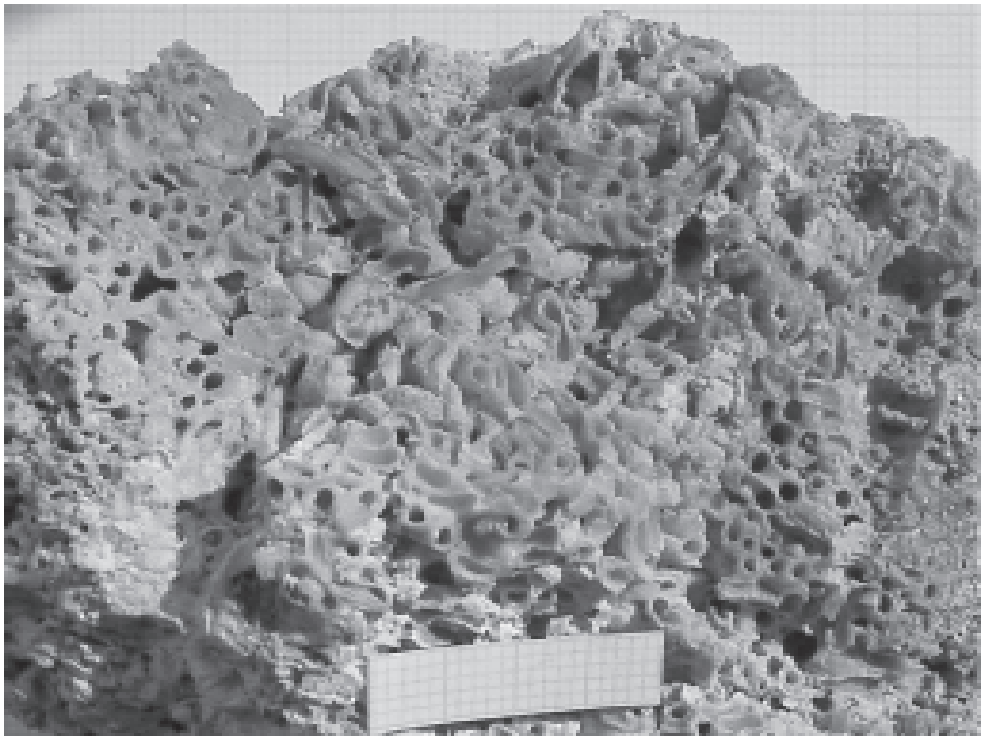

Figure 2.- *Dendropoma* sp. Last-Interglacial of «Punta del Tigre», Jandía. Fuerteventura Island. Scale bar: 2 cm.

Sal island, the range is only 0.65‰ for the C, and 0.56‰ for the O. This may be due to the taxonomical difference, and/or to environmental changes while the various sampled individuals grew. Ranges in Last-Interglacial samples show little differences from Sal island (0.36‰ for C and 0.31‰ for O), to Lanzarote (ranges C=0.47‰; O=0.15‰), and Fuerteventura (C=1,02‰; O=0.30‰).

Lighter average values of ä^{13}C in samples of Last-Interglacial age from Lanzarote (1.26‰) as compared with Fuerteventura (2.05‰) probably reflex stronger continental influence. Last-Interglaciar samples of Sal island have values of 2.08‰, whereas the recent shells of this island are the heaviest: 2.60‰. The lightest isotopic C values correspond to recent *Dendropoma petraeum* from Cabo de Palos (0.40‰). These differences can be related to environmental setting, or to *vital effect* differences between the Mediterranean *D. petraeum* and the Atlantic *Dendropoma* sp. It is also probable that the isotopic signal in Cabo de Palos is lighter due to the algal influence, because in the Mediterranean Sea, the coastal Vermetid concentrations are built by *D. petraeum* and the Coralline alga *Neogoniolithon notarisi* (Dufour) (Laborel, 1987).

Changes in the Oxygen isotopic signal of *Dendropoma* are related to variations in the temperature and/or salinity of the marine waters were they grew. Lighter $\delta^{18}O$ values in Last-Interglacial samples from Sal Island (0.13‰) are probably related to waters warmer than in Canary Islands. In contrast, the lighter $\delta^{18}O$ values in Lanzarote (0.71‰) as compared with that of the southern of Fuerteventura (0.93‰), located more to the South, are affected by larger fresh water run-off from the «Risco de Famara». This assumption is further supported by the lighter C isotopic signal in Lanzarote.

Differences between $\delta^{18}O$ of shells of the Last Interglacial (LI) from Fuerteventura (Canary Islands) with respect to that fo Cape Verde, if the salinity do not changed, probably reflects differences of 3-4ºC in the sea surface temperature (SST) during the LI between Fuerteventura and Sal islands. The recent differences of temperature between both islands are 5 ºC in February, and 4 ºC in Agost

Sample	$\delta^{13}C_{PDB}$	$\delta^{18}O_{PDB}$	Sample	$\delta^{13}C_{PDB}$	$\delta^{18}O_{PDB}$
DPCP-1	0,813	-0,992	SO3-6	2,113	0,402
DPCP-2	-0,164	0,604	SO3-7	1,864	0,142
DPCP-3	0,106	0,203	FAM-1	1,742	0,594
DPCP-4	-0,509	1,16	FAM-2	1,269	0,745
DPCP-5	0,276	0,987	FAM-3	1,535	0,269
DPCP-6	0,949	0,366	FAM-4	1,240	1,140
SAL-1	2,761	0,550	FAM-5	0,815	0,730
SAL-2	2,881	0,803	FAM-6	0,990	0,804
SAL-3	2,834	0,542	PT-65-1	3,555	1,067
SAL-4	2,394	0,431	PT-65-2	2,942	0,765
SAL-5	1,715	0,319	PT-651-3	1,671	1,030
SAL-6	2,106	0,235	PT-651-4	1,891	1,141
SAL-7	1,333	0,317	PT-651-5	2,444	0,668
SO3-1	2,463	-0,141	PT-651-6	0,978	0,904
SO3-2	2,254	0,174	PT-651-7	1,864	0,953
SO3-3	2,104	0,081	PT-651-7	1,864	0,953
SO3-4	1,778	0,159	PT-651-8	1,367	1,076
			PT-653-2	1,264	0,835

Table I.- Isotopic results. DPCP: Recent from Cabo de Palos, SAL: Recent from Sal island, SO3: Last Interglaciar (LI) from Sal, FAM: LI from Lanzarote, PT: LI from Fuerteventura**.**

LAST INTERGLACIAL		
Dendropoma sp. Fuerteventura	$\delta^{13}C$	$\delta^{18}O$
Range	3,57	0,47
Average values	2,05 ‰	0,93 ‰
Dendropoma sp. Lanzarote	$\delta^{13}C$	$\delta^{18}O$
Range	0,92	0,87
Average values	1,26 ‰	0,71 ‰
Dendropoma sp. Cape Verde	$\delta^{13}C$	$\delta^{18}O$
Range	0,76	0,64
Average values	2,08 ‰	0,13 ‰

RECENT		
Dendropoma petraeum (Mediterranean)	$\delta^{13}C$	$\delta^{18}O$
Range	1,11	2,09
Average val.	0,40 ‰	0,23 ‰
Dendropoma sp. (Cape Verde)	$\delta^{13}C$	$\delta^{18}O$
Range	0,65	0,56
Average val.	2,60 ‰	0,51 ‰

Table II.- Ranges and average values of isotopic signal.

(Gorshkov, 1978).

In Sal Island, the $\delta^{18}O$ values in samples of the same species of *Dendropoma* increase from the Last-Interglacial (0.13‰) to the recent (0.51‰). As salinity is not likely to have changed significantly, we conclude that the difference probably reflects a higher SST during the LI with respect to the recent, closely to 2 ºC, if ice-volume does not changed significativelly. In the mediterranean locality of La Marina (Alicante, East of Spain), the isotopic differences between LI with respect to the recent, recorded from the Bivalve *Arca noae*, suggest an increase of 4 ºC in SST during LI (Cabero, 2005). Martrat *el al*. (2004), based in the alkenone record of ODP Site 977A, situated in the Alboran Sea (Western Mediterranean), reported the same difference during OIS 5e and recent SST. This suggests that the difference between LI and the recent SST in the Western Mediterranean was higher SST than in the more ecuatorial area of Cape Verde. Nevertheless, Pérez-Folgado *et al*. (2004), reported a difference of 2 ºC in SST between the LI and the recent, based in the *modern analog* techniques applied to planktonic Foraminifera from ODP Site 977 A.

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